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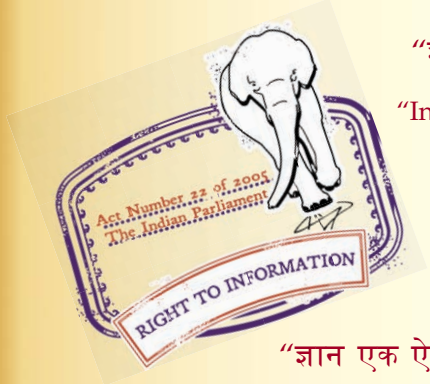
IS 10386-10 (1983): Safety code for construction, operation and maintenance of river valley projects, Part 10: Storage, handling, detection and safety measures for gases, chemicals and flammable liquids [WRD 21: Safety in Construction, Operation and Maintenance of River Valley Projects]



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"Knowledge is such a treasure which cannot be stolen"

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(Reaffirmed 2005)

Indian Standard

SAFETY CODE FOR CONSTRUCTION, OPERATION AND MAINTENANCE OF RIVER VALLEY PROJECTS

PART 10 STORAGE, HANDLING, DETECTION AND SAFETY MEASURES FOR GASES, CHEMICALS AND FLAMMABLE LIQUIDS

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PART 10 STORAGE, HANDLING, DETECTION AND SAFETY MEASURES FOR GASES, CHEMICALS AND FLAMMABLE LIQUIDS

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SAFETY CODE FOR CONSTRUCTION, OPERATION AND MAINTENANCE OF RIVER VALLEY PROJECTS

PART 10 STORAGE, HANDLING, DETECTION AND SAFETY MEASURES FOR GASES, CHEMICALS AND FLAMMABLE LIQUIDS

0. FOREWORD

0.1 This Indian Standard (Part 10) was adopted by the Indian Standards Institution on 18 April 1983, after the draft finalized by the Safety in Construction, Operation and Maintenance of River Valley Projects Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 Gases and chemicals play a vital role in the construction, installation and erection of different components of modern river valley projects. Discreet use of gases and chemicals can hasten the construction operations involving excavation in rock for the dam and its appurtenant works. The use of chemicals as explosives and air entraining agents in concrete and for epoxy treatment of the various components likely to remain submerged is common. Gases are also used extensively in activities like cutting, welding, diving, etc.

0.2.1 Hazards arising out of the misuse of chemicals (especially explosives) and gases are likely to result in accidents which may endanger the life of workers in the vicinity.

0.2.2 In construction, installation and erection operations of river valley projects, there are many inherent dangers to life and health of workers. The hazards may arise out of the use of dangerous gases and working in certain environments which expose the workers to serious risks. Workers employed in underground excavations on multipurpose projects may be suddenly exposed to atmospheric contaminants, gases and vapours of flammable liquids, for example, carbon monoxide, carbon dioxide, hydrocarbons, etc, leaking from nearby pockets of dangerous concentrations. Such environmental hazards can be controlled by identifying and locating them by taking appropriate engineering remedial measures and accordingly safety measures can be adopted.

0.2.3 Deficiency of oxygen in the working area is harmful, normal air contains 21 percent of oxygen and when the oxygen content in air is reduced to 19·5 percent, atmosphere becomes hazardous to human life. Workers may become dizzy, experience a buzzing noise in the ears and may develop a rapid heartbeat. This may be due to dilution or displacement of the air by other gases or vapours or because of loss of oxygen due to decay of organic matter, chemical reaction or natural oxidation over a long period of time. Oxygen content of the atmosphere in the confined space shall be determined by pre-entry and subsequent tests made with approved instruments. No one shall be allowed to enter or remain in a confined space where tests show less than 19·5 percent oxygen in the atmosphere, unless, one wears respiratory protective equipment conforming to IS : 8523-1977*.

1. SCOPE

1.1 This standard (Part 10) lays down the requirements regarding storage, handling, detection and safety measures for gases, chemicals and flammable liquids used in river valley projects.

2. COMPRESSED GASES

2.1 Gases like chlorine, oxygen, acetylene, carbon dioxide, ammonia, etc, are of immense use in these projects. Chlorine is used for disinfecting the drinking water. Ammonia is used in refrigeration plants and ice so produced is used in cooling of concrete. Carbon dioxide is used in fire fighting system. Cutting and welding processes using oxy-fuel gas flames are necessary part of river valley projects. Very often, however, persons who use or supervise these processes do not fully appreciate that their improper use may result in loss of life by fire explosion.

2.1.1 Safety aspects in the use of such gases, generally in compressed form, during the various stages of river valley projects have been discussed in **2.2** to **2.4**.

2.2 Storage — Compressed gases are usually contained in cylinders of different shapes and sizes. Gas cylinders are painted in different colours according to the contained gases to make the identification easier, following instructions shall be observed in the storage of cylinders :

a) A well ventilated store room shall be provided for handling and storage of cylinders. Empty cylinders shall be stacked away

*Specification for respirators, canister type (gas masks).

from full cylinders. 'Full' or 'Empty' notices shall be displayed on each relevant stack.

b) When stacking the cylinders vertically, it shall be ensured that they are properly secured by suitable brackets or stands so that they do not fall.

c) If cylinders are stacked horizontally, proper blocks shall be used at each end of stack to prevent their rolling. Large size cylinders shall be placed at the bottom. One vertical stack shall not contain more than four cylinders.

d) Cylinders shall not be kept in a battery charging room or in oil storage room or in places where there is a likelihood of oil, acid or any other corrosive liquid being splashed on them.

e) Cylinders shall be stored far away from sources of heat, such as furnaces, boilers and heating apparatus. Cylinders shall not be exposed to direct rays of the sun. Tarpaulin or any other cover shall not be used in direct contact with cylinders, as a protection against the sun.

NOTE — If cylinders are exposed to heat, the internal pressure will increase which may give rise to unsafe conditions particularly in the case of acetylene cylinders, in which the internal pressure increases by about $3{\cdot}13 \times 10^{-2}$ N/mm² for every degree centigrade rise in temperature. The pressure increase is caused due to decomposition of the acetylene which makes it more liable to cause explosion. It has been observed that acetylene at pressure in excess of 0·186 N/mm² starts decomposing due to shock or heat.

f) It shall always be ensured that the cylinders are protected from rusting or from corrosive conditions.

g) Cylinders shall not be directly placed on wet soil, proper dunnage shall be used.

h) It shall be ensured that cylinders do not come in contact with electrical apparatus or live wire.

j) Under no circumstances shall a cylinder used for storing one type of gas be used for storing another type. This is of paramount importance with such gases as oxygen on one hand and hydrogen or acetylene on the other. Mixing up of such gases would produce serious explosion risk.

2.3 Handling — Following instructions shall be observed in handling of cylinders:

a) Oil and grease ignite violently in presence of oxygen and may even lead to explosion in case oxygen is under pressure. Oxygen

cylinders and regulator fittings shall be kept away from all sources of contamination such as oil drums, storage batteries, paint drums, etc.

NOTE — It has been experienced that oily rags and cotton wastes which are in the vicinity at times lead to spontaneous combustion of an oxygen cylinder.

b) It shall be ensured that grit, oil dirt of any sort does not enter regulator assemblies.

c) Cylinder valves shall not be lubricated.

d) Only the standard key shall be used for opening the valves and the key shall be free from any oil or grease. Leverage of keys or spanners shall not be increased and no attempt shall be made to get gas from cylinders with broken valves thereby rendering the cylinder useless.

e) Cylinders shall not be used as rollers, work supports or jacks.

f) Cylinders shall not be loaded loosely in a vehicle as these will come in contact with each other and be subjected to jolting and damage during vehicle movement.

g) Cylinders shall be kept away from sparks, flames or slag from welding and cutting operations.

h) Cylinders which get damaged in transit or in the course of being used in the plant or for any other course shall be handled in the same manner as leaking cylinders.

j) Handling of acetylene cylinders shall need special attention, as acetylene is a highly flammable gas and in case it leaks, the acetylene-air mixture is likely to explode if ignited by flame, heat or spark present in the vicinity. Acetylene cylinders shall, therefore, be handled very carefully to prevent damage which might lead to bursting of cylinders or leakage through the cylinder valve. They shall not be banged, jolted violently, dropped or thrown about. When being unloaded from a truck, the cylinder shall be lowered gently.

2.3.1 *Unloading of Gas Cylinders* — Gas cylinders shall be handled with care. They shall not be dropped or allowed to strike against each other, to ensure safety. The following method of unloading gas cylinders from road vehicles or railway wagon is recommended:

a) Whenever possible, the cylinder shall be unloaded directly on a raised platform by rolling over a coir mattress.

b) If a suitable raised platform is not available, each cylinder shall be slided down over a heavily reinforced 15 cm thick coir mattress of about 2 × 1 m size taking care that the bottom end touches the mattress first and then it is rolled away over the mattress. Cylinders shall not be dropped from a height.

c) It shall be made sure that the first cylinder has rolled away before the next one is slided down.

d) Lifting magnet shall not be used for loading and unloading.

e) A fibre rope sling may be used to lift one cylinder but not more then one at a time, provided it is adequately strong and correctly adjusted to prevent slipping. Use of a chain sling is unsafe as it is very likely to slip, over a cylinder.

2.3.1.1 From the unloading platform to the store house or from store house to the plant, the cylinders shall be transported by means of a hand cart. Such a hand cart shall be provided with a chain, or belt for securing the cylinders in proper position.

2.3.1.2 If a cylinder is to be transported over a short distance and a suitable hand cart is not available, it shall be rolled over its bottom edge but never dragged.

2.4 Reporting of Gas Cylinder Accidents — In accordance with the provision of *Gas Cylinder Rules*, 1940, all accidents caused in using gas cylinders shall be reported to Chief Inspector of Explosives.

3. CHEMICALS

3.1 The chemicals have varied use in the multipurpose river valley projects in one way or the other, the chemicals are used in construction, erection and maintenance of different components of the project. Chemical compounds are widely used as explosives, acids, etc.

3.1.1 The transportation and storage of explosives and acids shall be governed by *Indian Explosives Act*, 1884 (including *Indian Explosives Rules*, 1940) and relevant Indian Standards.

3.2 Explosives

3.2.1 *General* — The use of explosives is very essential in all hard ground tunnelling and shaft sinking operations of river valley projects. Selection and judicious use of proper kind and quality of explosives is essential for success, safety and efficient progress of every job.

3.2.1.1 Proper storage of explosives and accessories is important not only to ensure that these materials are kept out of the reach of unauthorised persons and to reduce the hazards of accidental explosion but also to maintain them in good condition for use.

3.2.2 *Blasting Supplies* — A good quantity of other materials like detonators, detonating fuses and blasting leads are used to detonate an explosive charge or carry detonation from one charge of explosives to another. Such materials are termed as blasting supplies.

3.2.3 *Storage of Explosives* — Explosives and accessories are perishable goods which are liable to deteriorate after long storage, especially if subjected to high temperature and humidity. If kept ina moist place the compounds contained in the explosives may loose their power. It is due to this reason that underground magazines are not preferred in river valley projects. On the other hand, explosives shall also not be stored in a very dry place because, it may result in the explosives loosing the moisture they naturally contain, thereby changing the speed of the explosion. The storage of explosives shall be in accordance with the provisions of *Indian Explosives Act*, 1884, and the rules made thereunder, and the conditions given in the licence to be issued by the competent authority as laid down in above referred Act.

3.2.4 *Selection of Site of Magazine* — Magazine shall be kept away from the residential buildings, rail roads or highways, transmission lines, dams and their appurtenant works.

3.2.4.1 The safety distances required under the *Explosive Rules* shall depend on the storage capacity of the Magazine and may be adopted as per provisions of the Act/Rules. The best site for a magazine is on a well drained sloping ground.

3.2.4.2 The selected site shall be accessible by road. The magazine shall be located near the perennial source of sweet water. This is important where the guards are required to stay at site.

3.2.4.3 The construction and approval of the magazines shall be based on standard Indian practice as governed by *Indian Explosives Act*, 1884 and *Explosive Rules*, 1940.

3.2.5 *Storage of Different Classes of Explosives* — Storage of various explosives and accessories as classified in schedule I of *Explosive Rules*, 1940 shall be governed by the above referred rules.

3.2.5.1 On no account, however, detonators shall be stored together with the explosives.

3.2.6 *Maintenance and Operation of Magazines* — The following percautions shall be taken for maintenance and operation of magazines:

a) The magazines shall be scrupulously clean. The floor of the building shall be cleaned with a brush on each occasion the magazine is opened for delivery or receipt of explosives;

b) The magazine keeper shall always ensure that smoking material and matches are not taken into the magazine;

c) All the tools used in the magazines for opening of explosive boxes shall be of wood or soft non-ferrous metal such as brass, copper or bronze. Iron and steel tools are prohibited as they may cause sparking;

d) The area surrounding the explosives magazines shall be kept free from bushes and other vegetation;

e) Empty boxes, loose packing material or cotton waste shall not be kept in magazine's premises;

f) The magazines shall be well ventilated and it is advisable to keep magazines open every day for a period of one hour;

g) Detailed records of all outgoing and incoming stocks shall be kept. Explosives shall be used according to their dates of manufacture;

h) All magazines shall be securely locked, when not attended;

j) Packing cases of explosives shall be stacked on trestles, clear of floor and a 15 cm air space shall be left between the cases and walls to allow circulation of air;

k) Care shall be taken that repairs to the magazines are attended to on priority basis;

m) Every explosive magazine shall prominently display general rules governing conduct in magazine, indicating the necessity of over-shoes, prohibiting smoking or carrying of matches or any other rules that may be required by the local licensing authority. A copy of the licence and lightning conductor test certificate shall also be preserved in the magazine;

n) The magazine, on no account, shall be opened during or on the approach of a thunderstorm and no person shall remain in the vicinity of the magazine during such a storm; and

p) Magazines shall be guarded at all times.

3.2.7 *Handling of Explosives* — Explosives shall be transported in specially fabricated explosive van conforming to the provisions of *Explosives Rules*, 1940. The van shall bear the inscription 'EXPLOSIVE VAN' so as to warn the workers and the public. Before transportation from the magazine to the site of work it shall be ensured that the entire cargo is securely loaded. Metal tools, oil, matches, electric storage batteries, acids or other corrosive compounds, etc, shall not be carried in the body of the transporting vehicle. The van shall be equipped with fire extinguishers. At the back of van, there shall be two chains hanging from the body in such a way that all the time they touch the ground to provide necessary earthing for safety against lightning or short circuiting of the vehicle. In addition to the above all the provisions of *Indian Explosives Act* shall be fully complied with.

3.2.8 *Place of Loading and Unloading* — Loading and unloading of explosives shall be done at a safe distance from dwelling houses, power house buildings, transmission towers, stores of petroleum, stores of timber or any other flammable materials.

3.2.9 *Inspection of Explosive Van* — The explosive van used for transportation of explosives shall be inspected for following to determine that it is in proper condition for safe transportation of explosives:

a) Fire extinguishers shall be filled and in working order;

b) All electrical wiring shall be completely protected and securely fastened to prevent short circuiting;

c) Chassis, motor, pan and underside of the body of the vehicle shall be reasonably clean and free of excess oil or grease;

d) Fuel tank and feed line shall be secure and shall have no leaks;

e) Brakes, lights, horn, wind shield, wipers and steering apparatus shall function properly;

f) Tyres shall be checked for proper inflation and defects; and

g) The vehicle shall be in proper condition in every other respect and acceptable for handling explosives.

3.3. Detection of Unfired Explosives — When all the holes in a sequence/ circuit have been properly loaded, they are connected with individual detonators which are to be fired. The connections made are tested with a galvanometer.

3.3.1 If, a faulty circuit is indicated by the galvanometer test, the firing cable shall be disconnected from the galvanometer and the circuits shall be examined for faulty connections, if any. If faulty connections are

detected, these shall be rectified and the shot shall be fired after retesting, the circuit shall be split into two halves and each one of them tested for continuity. The defective half of circuit shall be further divided into two and test shall be repeated to detect faulty quarter. It shall be continued till four or five detonators remain in the faulty circuit, when each one of them shall be tested in turn to find out the fault. Having located the faulty detonator, the remaining circuit shall be connected in series leaving the faulty part out, and it shall be treated as misfire.

3.3.2 In the event of misfire, the entrance/entrances shall be fenced so as to prevent inadvertent access, and no work other than locating or relieving the misfired hole shall be done therein until the misfire has been located and relieved. In open cast workings, it shall be sufficient to mark the place of the misfire with a red flag.

3.3.3 Keeping in view that misfires are dangerous because they leave unfired explosives, every care shall be taken while loading and firing so as to minimize such an eventuality. However, on their occurrence, they shall be handled in the most competent and skilled manner. Having located, the misfired hole if it happens to be due to faulty cable or connection, the defect shall be rectified and shot fired again. In case, this fails, either of the following procedures shall be adopted:

a) The stemming shall be cleaned by blowing compressed air after removing the primer. A fresh primer shall then be inserted, stemmed and fired. Where a part of the stemming can be removed, a small charge shall be inserted and fired and this results in the original charge to be detonated or dislodged.

b) In case, the charge is still unexploded, another hole termed as reliever hole shall be drilled. On firing this reliever hole, the misfired charge shall be dislodged and subsequently recovered from debris. While dealing with a misfire in this manner, the end of fuse shall be tied to marker to ease recovery of the unfired explosives.

c) For larger diameter holes, containing the detonating fuse inside it, the stemming shall be removed to expose sufficient detonating fuse. A primer shall then be placed near the detonating fuse and fired. This result in setting off the detonating fuse and unfired explosives. Regulation 177 of the Explosives Manual shall be referred in this connection.

3.4 Acids and other Chemical Compounds — Some of the acids like sulphuric acid, hydrochloric acid and nitric acid, and chemical compounds like calcium carbide, acetone, air entraining agents, epoxy, etc, are widely used in the river valley projects. For storage, transportation, handling and safety aspects reference may be made to manufacturer's instructions.

4. FLAMMABLE LIQUIDS AND DANGEROUS GASES

4.1 General — The most common flammable liquids used in the river valley projects are kerosene, petrol, diesel, coal tars and various hydrocarbons.

4.1.1 Manufactured liquid and fluid commodities such as paints, floor polishes, cleaning solutions, driers and varnishes are considered flammable liquids and classified according to the flash points of the mixture. Precautions incident to their handling and use differ according to their flash points, volatility and the percentage that the flammable liquid bears to the whole.

4.1.2 Flammable liquids vapourise and form flammable mixtures when kept in open containers, when leaks or spills occur or when they are heated. The degree of danger is determined by the flash point of the liquid, concentration of the vapour in the air (whether the vapour-air mixture is in the flammable range or not) and possibility of a source of ignition at or above a temperature sufficient to cause the mixture to burst into flame. In the handling and use of flammable liquids, exposure of large liquid surfaces to air shall be prevented.

4.1.3 Liquids themselves do not burn or explode, but the vapour-air mixtures, formed when they evaporate are explosive. Therefore, handling and storing of those liquids in closed containers and avoiding exposure of low flash liquids in use are of fundamental importance.

4.1.4 As a safeguard against explosions, the tests shall be carried out for presence of flammable mixture in the containers. During construction of various underground work of river valley projects, it shall be ensured that the workers employed in the confined space are not exposed to risk due to presence of insufficient oxygen or flammable liquids/dangerous gases.

4.1.5 The tests shall also be carried out for presence of various flammable liquids/dangerous gases, so as to ensure safety during working in the vicinity. In case, the presence of dangerous gases/flammable liquids is indicated, safety measures shall be adopted immediately so as to avoid major mishap.

4.2 Locating Dangerous Gases/Flammable Liquids in the Containers/ Confined Pockets — Some times workers employed in river valley projects have to deal with dangerous gases/flammable liquids. Some of the processes (may be underground or overground) involve unavoidable or accidental contamination not only in the immediate work area, but also over a considerable territory.

4.2.1 The presence of vapours or fumes of dangerous gases shall be detected by the instruments in accordance with the relevant Indian

Standards. Flammable limits of some of the gases are given in Appendix A.

4.2.2 *Detection of Dangerous/Flammable Gases* — For detection of different dangerous gases following procedure shall be adopted:

a) *Detection of carbon monoxide* — This gas is one of the most toxic gases. It can be found whenever/wherever there is incomplete combustion of carbonaceous materials. Carbon monoxide gives no warning of its presence. Concentration of only 0·10 percent may produce unconsciousness in one hour and may prove fatal within two hours.

Carbon monoxide can be detected with the help of carbon monoxide indicator. It is a direct reading, self contained instrument for continuous and precise determination of small concentration of carbon monoxide.

This instrument utilizes a dehydrating canister to remove moisture from the sample and a catalyst cell where the carbon monoxide is oxidised to carbon dioxide. The heat of this reaction is proportional to the amount of carbon monoxide present and is measured by a number of thermo-couples in series with an indicating meter whose dial is calibrated in percent carbon monoxide.

b) *Combustible gases (acetylene, ammonia, hydrogen, etc)* — The combustible gas indicator is used to detect and measure these gases. The combustible gas indicator is available in four different models. All operate on the balanced electrical bridge principle in which two opposing arms are of platinum filaments. One of the filaments is exposed to gas sample. Any combustibles present are burnt, changing the temperature and consequently electrical resistance of the filament. This charge unbalances the bridge and measured by an indicating meter whose scale provides the reading in terms of percentage of the lower explosive limits of the gas in air.

Explosimeter has also a wide field of application wherever there is danger of gas explosions. If combustible gases are present, concentrations are immediately readable on the illuminated indicating meter. This instrument measures concentration of gases and vapours below the explosive range and indicates the presence of concentration within or above the explosive range.

c) *Hydrogen sulphide* — This gas is harmful in concentrations as low as 20 parts in a million parts of air. Therefore, its early detection is vital. Hydrogen sulphide detector is used for this

purpose. By squeezing the bulb, samples are drawn through a detector tube packed with a granular chemical agent. The chemical turns colour in the presence of hydrogen sulphide. The length of discolouration is directly proportional to the percent of gas in sample. Concentration of gas is accurately read on a graduated scale, calibrated directly, in parts per million and in grains per hundred cubic metre.

d) *Chlorine* — High concentrations of chlorine may cause immediate irritation and severe poisoning, low amounts are not immediately noticeable and prolonged exposure are likely to promote respiratory distress. Chlorine detector provides a quantitative method for determining chlorine concentrations.

e) *Methane* — It is a colourless and odourless gas occurring in nature as the chief component of natural gas. It is lighter than air and has specific gravity of 0·554 in relation to air. It burns readily in air forming carbon monoxide and water vapour.

The explosibility of methane gas is between 5 to 15 percent. There is no explosion when the percentage of methane is less than 5 percent because heat liberated by combustion is dissipated into the surrounding area rapidly enough to prevent flame propogation. There is no explosion when the percentage of methane is greater than 15 percent because enough oxygen is not present for rapid combustion. The percentage of methane required for maximum explosive voilence is 10 percent.

The detection of methane is done with the help of methanometer.

4.2.3 *Detection of Flammable Liquids* — Unless tests prove otherwise, flammable mixtures shall be assumed to be present in all tanks which have contained or have been exposed at any time to flammable liquids. Tests for flammable vapour-air mixtures in tanks/vessels and confined pockets may be made either by chemical analysis of samples or with a combustible gas indicator.

4.2.3.1 A combustible gas indicator is an instrument operating on the principle that when a mixture of flammable vapour and air is passed over a heated electric filament, the resistance of the filament will be increased in direct proportion to the amount of vapour present. When this filament is balanced against a cold filament in a wheatstone bridge device, resistance can be measured on a galvanometer in terms of the lower flammable limit of the mixture.

4.2.3.2 One type of combustible gas indicator has a meter with readings in parts of 100 percent, which represent percentage below the lower

flammable limit, of the vapour-air mixture being tested. When samples of atmosphere are drawn through the sample hose by the aspirator bulb, the meter will indicate whether or not the atmosphere is in the flammable range or below flammable limit.

4.2.3.3 A combustible gas indicator shall be used only by experienced persons and operator shall follow the manufacturer's instructions.

4.3 Safety Measures — When the presence of flammable liquids/dangerous gases is indicated, following safety measures shall be adopted:

a) Before taking up a river valley project, the detailed geological subsurface probing shall be carried out so as to know about the possibility of the presence of dangerous gases/flammable liquids.

b) Whenever the percentage of dangerous gases/flammable vapours is indicated in a working area/vessel, above the permissible proportions, all the persons working in the area shall be withdrawn and electricity cut off.

c) If there is any possibility of presence of dangerous gases/ flammable vapours while doing underground works/tunnelling in a river valley project, the permitted explosives and approved type exploders (as advised by the dealers) shall be used and flame-proof electric equipment and lights (as detailed in electricity rules) shall be installed so as to avoid sparking of loose connections. Lights shall be kept sufficiently away from the working faces. The battery locomotive may also be a source of ignition.

d) *Smoking* — Smoking and carrying of naked fires, matches, lighters or other spark producing devices shall not be permitted in the building, or area where flammable liquids/dangerous gases are stored, handled or used.

'NO SMOKING' signs in red letters shall be posted conspicuously in such buildings and areas.

e) *Ventilation and dilution* — All works, especially underground works in a river valley project shall have proper and efficient ventilation system. In case, the presence of dangerous gases/ vapours is indicated, the same shall not be brushed or wafted by any means and steps shall be taken to remove the gas by improving the ventilation by proper coursing through brattices, sheet, etc, after rendering it harmless by dilution through supply of air, if necessary.

The working area shall be examined for dangerous gases within 2 hours before the beginning and at least after every 2 hours during the working shift.

When there is a rockfall anywhere in the underground works, the safety measures mentioned above shall be immediately followed even if the proportions of such gases are within permissible limits before the rockfall. The work shall be restarted only after ensuring the accumulation of gases to be less than permissible proportions.

f) *Bonding and grounding* — To eliminate a spark from discharge of static electricity during filling operations, a wire bond shall be provided to equalize the potential between the storage container and the container being filled. In addition, it is advisable to have the bonding wire or one of the containers grounded.

Moving belts are sources of static electricity unless they are made of a conductive material or are coated with a conductive belt dressing compound designed to prevent static charges from being built up.

Non-conductive materials, such as fabric, rubber, or plastic sheeting passing through or over rolls also create charges of static electricity. Static from these materials as well as from belts shall be discharged with grounded metal combs.

g) *Preventing dangerous mixtures* — Accidental mixing of flammable liquids shall be prevented; for example, gasoline mixed with fuel oil may change the flash point sufficiently to make the fuel hazardous in ordinary use.

Control valves on equipment containing flammable liquids shall be identified by colour or tag or both.

Distinct strips or identification lettering shall be placed on the cans to help reduce the chance of liquids being mixed.

h) *Inhalation* — First aid boxes shall be readily available at site. If a worker has been exposed to dangerous gases like carbon monoxide or methane emanating from some hidden source in underground excavations, he shall be at once removed to an uncontaminated area. Under no circumstances shall a rescuer enter the site of excavation to remove a victim of over exposure without proper respiratory protection. If breathing has stopped, an effective means of artificial respiration shall be started immediately. If oxygen inhalation apparatus is available, oxygen shall be administered but only by a person authorised for such duty by a physician. The patient should be kept warm but not hot. Emergency procedure shall be established for summoning ambulance, physician or other agency promptly, so that such assistance will be enroute to the location before the rescue is accomplished.

Oxygen content of the atmosphere in the confined space shall be determined by pre-entry and subsequent tests made with approved instruments. No one shall enter or remain in a confined space where tests show less than 19·5 percent oxygen in its atmosphere or show presence of dangerous gases, unless he wears approved respiratory protective equipment such as a fresh-air hose mask or self-contained breathing apparatus conforming to IS : 8523-1977*.

j) The various life saving apparatus such as filter self rescuer, oxygen breathing apparatus, personal protective equipments, hats, boots, goggles, etc, shall be made available for use by workers employed in river valley projects where there is even slightest possibility of emission of any toxic gases or lack of permissible percentage of oxygen in the atmosphere in the underground works.

k) Due importance shall be given to educate labour of safety rules. Periodical safety meetings shall be held to exchange ideas and experience.

m) The various types of appliances required for fire protection shall conform to relevant Indian Standards. All preventive measures and availability of necessary appliances/material against fires shall be ensured at strategic points or as defined in the relevant Indian Standards.

APPENDIX A
(*Clause* 4.2.1)

FLAMMABLE LIMITS FOR DANGEROUS GASES

Gas	*Percent by Volume*
Acetylene	2·50 to 81·0
Ammonia	16·00 to 25·00
Carbon monoxide	12·50 to 74·0
Coal gas	5·3 to 32·0
Oil gas	4·8 to 32·50
Hydrogen	4·0 to 75·0
Hydrogen sulphide	4·30 to 45·0
Methane	5·0 to 15·00

*Specification for respirators, canister type (gas masks).